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BODY FAT CONTENT OF BOBWHITES IN RELATION TO FOOD PLANTINGS IN KANSAS

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Abstract:

A wildlife habitat improvement program was initiated on the Fort Riley Military Reservation in 1961 to increase winter food supplies for bobwhite quail (Colinus virginianus). As part of an ongoing evaluation of this program, 164 bobwhite quail were collected during the fall and winter of 1968-72 for fat analysis. Fat content in carcasses of birds collected <600 m from a food plot was compared with fat content of birds collected >900 m from a food plot.

During winter months, birds collected near a food plot were significantly ($P<0.10$ to $P<0.05$) heavier than birds not having access to a food plot. Fat content of birds close to a food plot was likewise greater ($P<0.10$ to $P<0.01$) than fat content in birds not using food plots. Calculations indicate that birds close to food plots have sufficient energy reserves to provide a 79% greater protection against brief periods of food deprivation than birds far from a food plot. Fat energy reserves alone in a quail close to a food plot could provide sufficient energy for 2.0 days of survival whereas quail far from food plots contained fat energy reserves sufficient for only 1.1 days of survival.

Reserve energy for animals is stored in the body mainly in the form of fatty acids. The quantity of stored reserve energy (fat) may be critical to the animal's survival during periods of food scarcity or extremely cold weather. Much work has been done on fat content, composition, and regulation in songbirds (8, 9, 10, 11, 12, 15, 16, 23, 24). Only recently has any attention been given to body fat reserves of wild gallinaceous birds under natural conditions. West and Meng (25) reported on the relationship of total fat and fatty acid composition to diet of willow ptarmigan (Lagopus lagopus) in Alaska while Moss and Lough (14) presented similar data for 3 species of grouse in Scotland.

Almost no attention has been given to fat reserves of bobwhite quail even though it is known that fat reserves may be essential for bird survival during periods of dietary stress (15, 23 and others). The most recent book on bobwhite quail (22) does not even discuss the importance of maintaining adequate fat reserves in quail for winter survival and spring breeding. In fact, not until only very recently has any attention been focused on basic energetics of bobwhite quail (3). Earlier I included a small amount of body-fat data in an evaluation of food plantings for bobwhite quail in Kansas (18). The purpose of the study described herein was to gather more extensive data on body fat content in bobwhite quail, especially as related to seasonal changes and food plantings in Kansas.

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Methods

This research was conducted on the Fort Riley Military Reservation in Riley County, 8 miles southwest of Manhattan, Kansas. The Reservation is on the western edge of the Kansas Flint Hills. Vegetation and topography of the area are described in Robel (18). A wildlife habitat improvement program was begun on the Reservation in 1961 mainly to benefit bobwhite quail and is still somewhat active. Early studies (21) disclosed a shortage of winter food (seeds) for wildlife, and therefore the primary purpose of the habitat improvement program on the Reservation was to increase the availability of seed sources for bobwhite quail and other granivorous wildlife.

Plantings of corn, wheat and sorghum were established on the Reservation by military personnel. Normally a food plot consisted of a combination of corn and sorghum, but sometimes corn, sorghum, and wheat were planted adjacent to each other. Early in the study, food patches were small (0.52 acres each) and scattered over the entire Reservation except for a central artillery impact area. During 1965 and 1966, several long narrow plots (up to 2 miles long) of corn and sorghum were established, in addition to the many small and isolated food patches, to utilize available large equipment more effectively. Total area producing cultivated grain for wildlife varied from year to year, ranging from 150 to 300 acres. All planted grain was left standing for the entire winter.

Beginning in 1961 bobwhite quail were collected regularly during fall, winter and spring. Birds collected prior to 1968 were used to determine food habits (18), weight dynamics (18,20), winter mortality (17, 19), and helminthic burdens (6). Birds collected after 1968 were used to provide body fat data in addition to the information listed above. Sporting firearms were used to kill the quail and bird dogs helped in locating coveys and retrieving cripples. Collecting was normally limited to late afternoon hours and no more than 2 quail were taken from any 1 covey on the same day. Time and location of kill plus sex and age were recorded for each bird collected. Exact kill locations were determined in the field by using military coordinates on contour maps having a scale of 4 inches per mile. Tip coloration of the greater upper primary feathers (13) and appearance of the seventh greater primary coverts (7) were used as criteria to distinguish juveniles from adults. Sex was determined by body plumage characteristics.

Bobwhites were weighed within 3 hr of the time they were killed. Crop contents were removed prior to weighing the bird to the nearest 0.1 g.

Carcasses were quick-frozen and stored at -20 C until analyzed for body fat. Each bird was analyzed individually. While frozen, birds were sawed lengthwise and processed through a universal No. 3 food chopper (fine cutter). The chopped material was then dried 24 hours at 60 C, again processed through the chopper and thoroughly blended. Moisture-free weight was determined after drying 2-g samples for 5 hr at 110 C under vacuum (28 inches of Hg). Fat was extracted from 2 2-g samples of each bird in a Goldfisch extraction apparatus for 16 hr using anhydrous diethyl ether as a solvent. Samples were then redried at 110 C for 5 hours under vacuum and reweighed. Ether-extractable fat was expressed as a percentage of dry tissue weight.

Weights (g) and fat content (%) are expressed as mean ± standard error.

Results and Discussion

Body fat determinations were made on 164 quail carcasses during the 1968-72 collecting period (Table 1). Of the 164 total, 79% were juveniles and 21% were adults. Males and females were represented equally in the sample but adult/juvenile ratios were not the same for each sex (Table 1). Because of small sample size in each month of each year (range 0 to 6), birds were pooled by month for the 4-year study. Although sample pooling masks year-to-year differences and also prevents detecting any age or sex differences, it does provide adequate sample sizes for meaningful analysis. Weights of bobwhites collected for fat analysis varied seasonally (Table 2). Birds collected in September weighed the least (178.2 ± 4.2 g) whereas those collected in December were heaviest (196.3 ± 3.3 g). These data are similar to more extensive quail weight data presented by Robel and Linderman (20) and Robel (18) for bobwhites collected on the same study area.

Content of ether-extractable fat in carcasses of bobwhites varied seasonally. Fat content was lowest in birds collected in September (7.29 ± 0.35%), gradually increased during October, November and December, and reached a peak in January (20.13 ± 1.69%). Fat content gradually decreased after January, to 16.75 ± 1.22% in February and 14.46 ± 2.46% in March. The highest amount of ether-extractable fat (37%) was found in a juvenile bobwhite collected in January 1969. Twenty quail contained more than 25% fat; 85% of these birds were collected during December and January. The least amount of fat (3.6%) was found in a juvenile male collected in December 1969. Fifteen quail contained less than 6% fat; 47% of these birds were collected in March whereas 20% each were collected during September and October, respectively.

The relationship between quail body weight and fat content was analyzed. No significant (P>0.10) relationship existed between the 2 parameters when weights and fat content of all birds collected between September and March were included. However, a significant (P<0.01) positive correlation was detected in birds collected only during the winter months (January-March).

Relationship with Food Plots

Earlier (18) it was determined from crop content that birds within 600 m of a food plot commonly utilized the plot as a food resource. Birds within 600 to 900 m of a food plot occasionally fed in the plot, whereas birds collected farther than 900 m from a food plot never used the plot as a food resource. Therefore, the effectiveness of food plots can be evaluated by comparing birds collected within 600 m of plots with those collected 900 m or more from plots. Birds killed in the 600-to-900 m distance class are omitted from the comparison since they occasionally utilized food plots.

Of the 164 birds collected and analyzed for fat content during this study, 78 were collected within 600 m of food plots and 76 were collected 900 m or more from plots. Weights of birds collected within 600 m of plots were not significantly different (P>0.10) from those of birds killed 900 m or more from plots during the September to December period; however, birds killed close (0.600 m) to plots in January, February and March weighed significantly more (P<0.10 to P<0.05) than birds killed far (>900 m) from plots (Table 1). The weight difference in January was 9.7 g, that for February was 6.4 g, and the weight difference in March was 10.8 g. The mean weight difference for the 3-month winter period was 9.0 g, i.e., on an average, birds killed close to food plots weighed 9.0 g more than birds killed farther than 900 m from plots.

The seasonal weight changes exhibited a quadratic relationship (Fig. 1). Weights of birds killed close to food plots reached a peak in January whereas weights of birds killed more than 900 m distant from plots peaked in December (Table 2). Although weights of birds collected close to and far from plots decreased during the winter, weights of birds killed close to plots decreased less than those of birds killed more than 900 m from plots (Fig. 1).

A comparison of the amount of ether-extractable fat contained in the bodies of birds killed close to and far from plots disclosed a relationship similar to that of the weight comparison described above. Fat content of birds killed within 600 m of plots was not significantly different (P>0.10) from fat content of birds killed more than 900 m from plots during the September-December period (Table 3). Birds killed close to plots during the January-March period all had a significantly greater (P<0.10 to P<0.01) amount of body fat than did birds killed more than 900 m from plots. Birds killed close to plots had an average of 20% body fat during January-March whereas birds killed far from plots during the same period contained only 13% body fat. Therefore, during winter, birds near plots had 1.5 times the fat content of birds killed more than 900 m away from plots.

Ether-extractable fat content of birds close to plots reached a peak in January while fat content of birds far from plots peaked in December (Table 3). As with bird weights, body fat of birds close to and far from plots decreased in late winter; however, the magnitude of the decrease was less among birds close to plots compared with birds far from plots (Fig. 2).

Since both bird weight and fat content exhibited a quadratic relationship with season, one would expect body weight and body fat content to be correlated. An analysis of these variables disclosed such a relationship, significant at the $P<0.01$ level, for all birds and for those killed within the 2 distance classes. During winter months (January-March), the slopes of the linear regressions were different ($P<0.01$) for birds killed close to plots and for those killed farther than 900 m from plots (Fig. 3). The steeper slope (and higher value) exhibited by birds killed close to plots might have resulted from the greater amount of fat contained in these birds. Minor day-to-day weight changes in birds close to plots could be accomplished by a fluctuation in fat content of that bird whereas changes in weight of a lean bird might not be possible by changes in fat content alone.

Importance of Fat Reserves

Fretwell (4) has shown that year-to-year survival of fat birds is greater than survival of lean birds. Such should not be surprising since fat is essentially reserve energy for a bird. Data collected during my study showed that birds living near food plots have more energy reserves during the critical winter months than birds living farther than 900 m from plots. By incorporating these field data with laboratory bioenergetics data for bobwhite quail (3), it is possible to evaluate the importance of these energy reserves to bobwhite quail. It is assumed that energy reserves will be of greatest value during winter months, therefore, I will compare the "starvation protection" afforded by fat reserves of bobwhites collected near food plots with that of bobwhites collected more than 900 m from a food plot. For this example, I will assume an ambient temperature of 5 C (representative of the January-March period in Knasas), a 190-g quail whose dry weight is 40% of its wet weight, a quail with a fat content of 15% of its dry weight, and an energy need 1.3 X the existence-energy requirement of a confined quail. This 190-g quail would require 60.74 kcal (46.72 kcal X 1.3) of energy per day (3). For this example, I am assuming further that only stored fat constitutes an energy reserve (not true in fact), that all but 3% of the fat in the bird is available for use as reserve energy, and that metabolism of 1 gram of fat by the quail produces 9.3 kcal of energy for the bird. Based on these conditions, this bird would be able to withstand complete starvation for approximately 1.4 days by existing on his stored fat energy alone. The calculations are shown below.

190 g quail X 0.40 dry wgt = 76 g dry wgt

76 g dry wgt X 0.12 fat = 9.12 g metabolizable fat reserves

9.12 g fat X 9.30 kcal/g = 84.82 kcal reserve energy

84.82 kcal ÷ 60.74 kcal/day = 1.40 days of reserve energy

By substituting actual field data obtained in this study wherever possible in the above calculations, the "starvation-protection" afforded wild bobwhite quail by food plots can be estimated.

Birds at <600 m from a food plot

193.2 g quail X 0.40 dry wgt = 77.3 g dry wgt

77.3 g dry wgt X 0.17 fat = 13.14 g metabolizable fat reserves

13.14 g fat X 9.30 kcal/g = 122.18 kcal reserve energy

122.18 kcal ÷ 60.74 kcal/day = 2.01 days of reserve energy

Birds at >900 m from a food plot

184.1 g quail X 0.40 dry wgt = 73.6 g dry wgt

73.6 g dry wgt X 0.10 fat = 7.36 g metabolizable fat reserves

7.36 g fat X 9.30 kcal/g = 68.48 kcal reserve energy

68.48 kcal ÷ 60.74 kcal/day = 1.13 days of reserve energy

Seldom do conditions exist in which quail can obtain no food whatsoever. Likewise, some energy can be obtained by the catalysis of proteins in the body, and energy can be conserved by reduced activity and covey formation (3). Disregarding these variables, or assuming they are constants for birds within 600 m of a food plot and birds 900 m or more distant from a food plot, it is possible to use the results of the above calculations to reflect the effectiveness of food plots for bobwhite quail on the Fort Riley Military Reservation. Regarding fat reserves alone (excluding 3% unavailable fat), quail close to a food plot during winter have 13.14 g of fat reserves while those far from a food plot have only 7.36 g. Therefore, birds close to food plots have more reserve energy, providing a potential "starvation protection" 79% greater than birds not having access to a food plot. These extra reserves of energy are no doubt extremely important for bird survival during periods of winter cold and food shortage.

Although the effect of low energy reserves on reproductive behavior has not been studied intensively in bobwhites, data from research on ring-necked pheasants (Phasianus colchicus) indicate possible effects. Breithenbach et al. (2), Gates and Woehler (5), and Barrett and Bailey (1) reported that food restrictions resulting in weight losses in late winter could retard the onset of egg-laying in ring-necked pheasants. Furthermore, Breitenbach et al. (2) and Gates and Woehler (5) reported a reduction in total egg production in ring-necked pheasants which were in poor condition due to a limited energy intake.

Obviously there is a need for controlled research on the influences of fat reserves on bobwhite quail survival and reproductive success. I hope results presented in this paper will stimulate work in this interest.

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Table 1. Monthly distribution by sex and age of 164 bobwhite quail analyzed for body fat during this study.

Month	1968-69				1969-70				1970-71				1971-72				Entire study				Pooled
	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	
September	--	4	1	6	--	1	--	1	--	--	--	--	--	--	--	--	--	5	1	7	13
October	--	--	--	--	1	4	1	4	1	4	1	5	--	--	--	--	2	8	2	9	21
November	1	6	--	3	--	--	--	--	--	--	--	--	1	4	1	4	2	10	1	7	20
December	--	--	--	--	--	6	1	3	2	2	1	5	1	2	1	4	3	10	3	12	28
January	2	5	--	2	2	2	1	6	1	2	1	5	2	--	--	--	7	9	2	13	31
February	--	--	--	--	1	3	1	3	2	1	1	4	--	4	--	4	3	8	2	11	24
March	3	3	--	3	2	4	2	3	--	3	--	4	--	--	--	--	5	10	2	10	27
Totals	6	18	1	14	6	20	6	20	6	12	4	23	4	10	2	12	22	60	13	69	164

Table 2. Weights (grams) of all bobwhite quail analyzed for body fat; as well as those collected within 600 m of food plots, and those collected 900 m or more from food plots.

	All Birds		Distance from food plots 1/			
			0 to 600 m		>900 m	
Collected	N	Weight ± S.E.	N	Weight ± S.E.	N	Weight ± S.E.
September	13	178.2 ± 4.2	1	162.3 ± --	8	176.1 ± 4.0
October	21	184.0 ± 2.5	15	183.9 ± 3.4	2	184.6 ± 2.2
November	20	191.2 ± 3.6	13	195.5 ± 4.2	7	187.3 ± 5.2
December	28	196.3 ± 3.3	11	192.8 ± 3.3	17	198.6 ± 5.0
January	31	191.9 ± 2.0	15	197.4 ± 3.6**	15	187.7 ± 3.1
February	24	193.8 ± 2.5	10	194.5 ± 2.3*	13	188.1 ± 2.6
March	27	183.1 ± 3.3	13	187.4 ± 3.1**	14	176.6 ± 3.6

1/ Birds killed between 600 and 900 m of a food plot excluded (see text).

* Significantly greater ($P<0.10$) than weight in other distance class.

**Significantly greater ($P<0.05$) than weight in other distance class.

Table 3. Content of ether extractable fat in carcasses of all bobwhite quail collected during this study as well as those collected within 600 m of a food plot and those collected farther than 900 m from a food plot.

	Ether extractable fat (percent dry weight)					
	All birds		Distance from food plots 1/			
			0 to 600 m		>900 m	
Month collected	N	Percent ± S.E.	N	Percent ± S.E	N	Percent ± S.E.
September	13	7.29 ± 0.35	1	7.79 ± --	8	7.23 ± 0.47
October	21	9.45 ± 1.19	15	9.78 ± 1.50	2	7.01 ± 0.33
November	20	12.90 ± 0.98	13	13.63 ± 1.29	7	11.52 ± 1.43
December	28	17.30 ± 1.39	11	14.50 ± 2.11	17	19.12 ± 2.07
January	31	20.13 ± 1.69	15	24.43 ± 2.23**	15	16.37 ± 2.16
February	24	16.75 ± 1.22	10	19.35 ± 2.18*	13	14.75 ± 1.26
March	27	14.46 ± 2.46	13	15.40 ± 1.26***	14	9.37 ± 0.80

1/ Birds killed between 600 and 900 m of a food plot excluded (see text).

* Significantly greater ($P<0.10$) than fat content of comparable birds in other distance class.

** Significantly greater ($P<0.05$) than fat content of comparable birds in other distance class.

***Significantly greater ($P<0.01$) than fat content of comparable birds in other distance class.

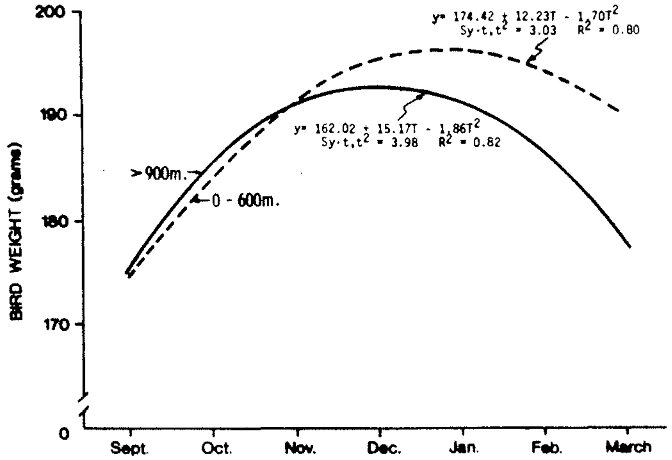

Fig. 1. Comparison between weights of 78 bobwhites collected within 600 m of a food plot and the weights of 76 birds collected more than 900 m from a food plot.

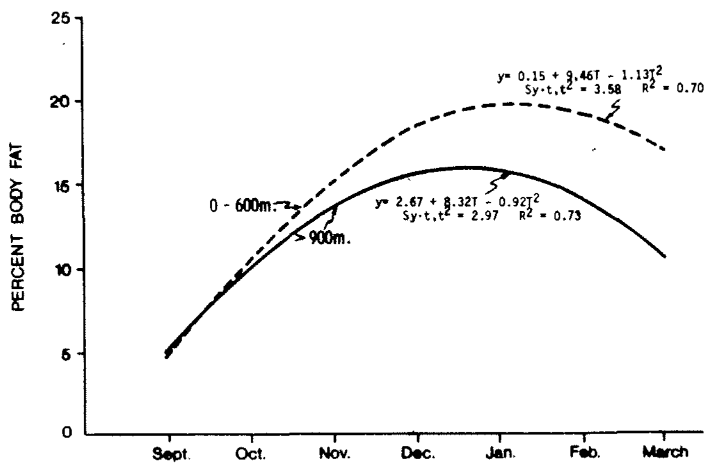

Fig. 2. Percent (dry weight) ether-extractable fat in carcasses of 78 bobwhites collected within 600 m of a food plot compared with fat content in 76 quail collected over 900 m from a food plot.

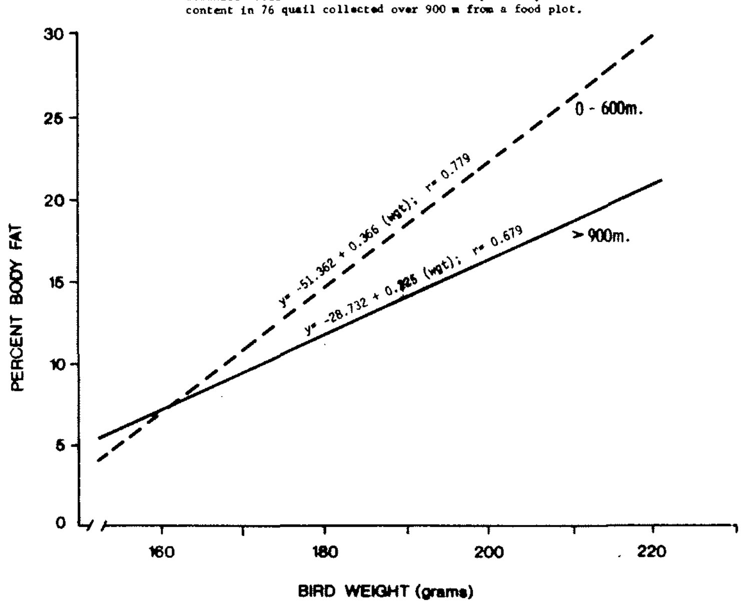

Fig. 3. Relationship between ether-extractable fat and weights of bobwhites collected during winter (January-March) within 600 m of a food plot and farther than 900 m from a food plot. Both correlation coefficients are significant (P<0.01).